Investigation of North-Side-Up Reverse Faults of the Seattle Fault Zone Using Uplifted and Offset Wave-Cut Platforms: Collaborative Research with Humboldt State University and U. S. Geological Survey

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Investigations Undertaken

This research in progress will document, using leveling surveys, augering and radiocarbon dating, the occurrence and timing of north-side-up reverse fault earthquakes along the Seattle fault zone. At several localities, scarps of north-dipping reverse faults intersect the coastline where a 1,100 year-old raised platform is preserved. Because the raised platform is the geomorphic signature of a ca. 1,100 year ago regional coseismic uplift (Bucknam et al., 1992) and because the Holocene scarps represent multiple late Holocene earthquakes (Nelson et al., 2003), the intersection of fault scarps and uplifted wave-cut platforms are critical locales for further understanding the chronology and nature of faulting in the Seattle urban area. We will investigate deformed wave-cut platforms at two coastal study sites that intersect north-side-up reverse fault scarps, one at West Seattle and the other on the west coast of Bainbridge Island.

We will assess the likelihood that the north-side-up reverse faults of the Seattle fault zone are seismogenic. Through our field data collection, we will evaluate the relation between coseismic uplift localized to the upthrown side of reverse faults with surface scarps and more regional coseismic uplift that is inferred to be associated with sub-horizontal blind faults at depth (Pratt et al., 1997; Brocher et al., 2004).

Preliminary Results

West Seattle

The West Seattle fault trends east-west and cuts across an emergent, tectonically uplifted late Holocene shore platform on the coast 2.4 km southeast of Alki Point. We used an auto level to profile the fault scarp and a hand auger to probe to the contact between the overlying beach sand and underlying uplifted shore platform on both sides of the fault scarp (16 augered exploratory holes). The surface scarp is 2.1 m in height and the offset on the shore platform is 1.4 m. Because offset of the shore platform underlies the surface scarp, we infer

that the West Seattle scarp is indeed a north-side-up fault scarp. We have yet to recover a radiocarbon sample for the beach sand; however, we infer that the uplifted shore platform dates from 1,100 years ago because that is the reported age for the regionally uplifted platform (Bucknam et al., 1992). Further work at this site will include additional augering on either side of the fault and excavation of soil pits to collect radiocarbon samples. Also, we will investigate the possibility that there are two uplifted shore platforms on the north side of the fault scarp. However, the site of a possible older, higher platform is extensively covered by landslide debris from the paleo sea cliff to the east and it is unlikely that we will resolve the issue of whether an older, second uplifted platform occurs north of the fault scarp.

West Coast of Bainbridge Island

We conducted detailed surface profile surveys and subsurface investigations at two coastal sites on Bainbridge Island, one 30 m south of where the Toe Jam fault intersects the west coast and the other 100 m north of where the Toe Jam fault intersects the west coast. Surface surveys across the shore platforms were carried out with an auto level and tied to the tidal bench mark at Port Townsend by surveying through a tidal minimum. Subsurface surveys were accomplished through excavation of five 1-m-by-1.6 m soil pits to depths of 1.5 - 3.2 m, soil pits were extended by augering down from the base of the pit. Stratigraphy in the soil pits, which is elevationally tied to the tidal datum through our surveys, revealed thickness of artificial fill above uplifted beach deposits, thickness of beach deposits and elevation of the shore platform (contact between uplifted beach deposits and underlying glacial sediment. In all cases, the shore platform was cut on glacial sediment; pending radiocarbon dates will indicate age of the glacial sediment.

The most significant finding is that there are at least two shore platforms immediately north of (100 m north of) the fault scarp but only one shore platform south of (30 m south of) the fault scarp. There may be a third, oldest and highest shore platform north of the fault scarp; additional field work will test the presence of a third platform.

The lowest shore platform north of the fault scarp is at the identical elevation as the only shore platform south of the fault scarp, meaning that, at least locally, the earthquake that regionally raised the shore platform on the coast of southern Bainbridge Island did not offset the Toe Jam fault at the west coast. The second oldest platform north of the fault is offset by Toe Jam fault because the equivalent platform is not preserved south of the fault. Survey of the elevations of the shoreline angles of the platforms (platform/paleo sea cliff junction) on either side of the fault scarp indicates that the second oldest platform north of the fault has been vertically offset along the fault scarp by 2.5-3.5 m. In addition, the second oldest platform north of the fault is not a regionally uplifted platform; the platform drops in elevation and merges with the lower platform 400 m northwest along the coast from the fault scarp.

The best interpretation to account for observations on number of shore platforms on either side of the fault scarp, the amount of platform offset and the regional extent of the oldest platform is that the shore platforms on the west coast of Bainbridge Island have been deformed by two types of earthquake. One type causes regional uplift of the island as testified by the regional uplifted shore platform that fringes Bainbridge Island (Bucknam et al., 1992). The second type of earthquake does not regionally uplift the island but does cause localized displacement on the Toe Jam fault. The second earthquake type is exemplified by the older platform north of the Toe Jam fault, which is offset by the fault but is not regional in extent. The Toe Jam fault is one of several late Holocene north-side-up reverse faults that characterize surface faulting along the Seattle fault zone. Based on research to date, we conclude that the north-side-up reverse faults are seismogenic structures

on their own and coseismic slip on the north-side-up reverse faults need not be triggered by slip on underlying low angle faults of the Seattle fault zone.

Non-technical Summary

Earthquakes in the Puget Lowland (Washington) along the Seattle fault zone have generated east-west trending, north-side-up fault scarps. At West Seattle and on the west coast of Bainbridge Island, we have surveyed the fault scarps and dug excavations on either side of the scarps at two localities where the fault scarps intersects the coastline. Through these surveys and excavations, we infer that the fault scarps can be generated by two types of earthquakes, a deeper earthquake that involves slip on a horizontal fault at depth and a shallower earthquake that is confined to a steeper fault that intersects the surface.

Reports Published

None to date.

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